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Materiel Test Procedure 5-2-515
White Sands Missile Range

U. S. ARMY TEST AND EVALUATION COMMAND
COMMON ENGINEERING TEST PROCEDURE

MISSILEBORNE PRESSURE ALTIMETERS

1. OBJECTIVE

The objective of this MTP is to determine limitations and characteristics of missileborne pressure altimeters.

2. BACKGROUND

The ultimate success of a missile flight is dependent upon the proper functioning of each component. Thus, it is necessary that specific evaluation tests be conducted on altimeters to determine suitability for installation in a missile system. Appendix A contains a description of the basic type of altimeter used in aircraft and missile control systems.

3. REQUIRED EQUIPMENT

a. Counter
b. Direct Writing Recorder
c. Distortion Analyzer
d. Hand Valve
e. High Potential Tester
f. Manometer (Absolute Pressure Reading)
g. Manostat Regulator (Aneroid)
h. Megger
i. Servo Monitor Amplifier
j. Oscilloscope
k. Pressuregraph
l. Resistance Bridge
m. Synchronous Motor
n. Three-way Solenoid Valve
o. Vacuum Pump
p. Variable Speed Motor
q. Voltmeter

4. REFERENCES

A. NACA Report No. 538, National Advisory Council for Aeronautics Report of Altitude-Pressure-Temperature Based on U. S. Standard Atmosphere, 1935.
B. MTP 5-2-516 Pressure Transmitters

5. SCOPE

5.1 SUMMARY

The procedures contained in this Material Test Procedure (MTP) are guides for evaluating missileborne pressure altimeters of the type that are

designed to sense the value of atmospheric pressure at a preset flight level. These altimeters interpret the sensed value in terms of distance above or below the preset flight level.

The procedures are described to the extent necessary to thoroughly test altimeters to the degree of accuracy required by applicable specifications. The tests leave common judgement to test personnel in regard to specific safety practices, altimeter peculiarities, and laboratory techniques. The following tests are described:

a. Resistance, Output Impedance, and Insulation Tests - Establish that circuit resistance, output impedance, and insulation resistance comply with specification requirements.

b. Dielectric Test - Ensure that insulation breakdown does not occur at a lower voltage versus time stress than specified.

c. Null and Quadrature Voltage Test - This test is conducted to determine the altimeter null voltage at various altitude levels and to correlate the preset dial settings in each case. It is further conducted to determine the component of quadrature voltage existent at minimum output or null which, if too great, may result in circuit parts saturation or polarity reversal.

d. Gradient and Linearity Test - Determine the gradient or scale factor at preset reference levels and establish linearity or deviation around that level.

e. Hysteresis and Striction Test - This test is designed to assist in the evaluation of the effects of any physical strain such as a pulsing pressure repeatedly applied to the altimeter aneroid diaphragm. Evaluation analysis is accomplished by comparative studies of a series of gradient curves for maximum deviation.

f. Absolute Accuracy Test - Determining the absolute accuracy of the preset dial indexes by making a statistical analysis of data obtained while the altimeter altitude reference level is held constant at sea level pressure and the altimeter flight level preset dial varied in intervals between the zero and maximum range setting.

g. Polarity, Phase Shift and Reversal Test - Determine that phase shift or reversal does not occur except when passing through null, for altitudes simulated above and below the setting of the flight level preset dial.

h. Waveform Test - Determine that the harmonic distortion of the output waveform is within specification requirements at maximum output voltage.

i. Leakage Test - Determine that the altimeter leakage rate is within specification tolerance.

j. Transient Response Test - Determine the damping characteristics of the altimeter in response to a step voltage input.

k. Frequency Response Test - Determine the altimeter response characteristics to a continuously varying pressure of sinusoidal waveform during frequency variation over a prescribed range.

l. Life Cycling Test - Determine the number of cycles of operation the altimeter can endure and properly operate within specification requirements.

5.2 LIMITATIONS

This MTP is limited in scope to only those altimeters that are designed to sense the distance above or below a preset altitude. Altimeters that indicate true altitude by sensing absolute pressure are similar to ordinary pressure transmitters and generally are tested in accordance with the procedures discussed in MTP 5-2-516 Pressure Transmitters.

6. PROCEDURES

6.1 PREPARATION

6.1.1 General

The following general procedures shall be used throughout the various phases of testing:

a. Prior to performing altimeter tests, personnel shall ensure that applicable manufacturers instructions and/or specifications shall be available for the altimeter to be tested.

b. When necessary, operating instructions shall be available for this equipment.

c. The operator of the test equipment shall familiarize himself in the use of equipment and must comply with pertinent operating instructions.

d. Assure that a log folder is set up for each altimeter in order that pertinent information and results shall be recorded during test.

e. Use standard safety practices to avoid personal injury or damage to equipment.

f. Consult all pertinent paragraph, table, and figure references, prior to commencing a particular test, to prevent risk of equipment damage or test failure through lack of instructions or misunderstanding.

g. Whenever possible, conduct the same tests on all altimeters of a similar type with the same test configuration before proceeding to the next test. This practice will save time and help in correlating the test results.

h. The configuration setup used for a particular altimeter shall not be distrubed until data have been reduced and recorded.

i. All adjustments in static pressure shall be made at the manostat pressure regulator.

j. All measurements of static pressures shall be taken at the manometer. Depending on the manometer used, the measurement shall be indicated in inches of mercury (in. Hg.) or in millimeters of mercury (mm. Hg.).

k. All flight level indications or altitudes simulated shall be measured in meters or feet, depending on the type altimeter under test.

l. All output voltage measurements shall be made using a voltmeter unless otherwise specified in the test procedure.

m. Visually examine the altimeter for and record any evidence of corrosion, physical damage, and non-conformance with design specifications. Identify each terminal of the altimeter on an electrical schematic. Determine voltage requirements and input and output circuitry.

o. A log folder will be utilized for each altimeter tested. Enter all test data in this log.

p. Record the following for each altimeter test:

1) Number of starts on each test
2) Date
3) Running time

q. The charts, graphs and conversion calculations explained in paragraph 6.4 will become a permanent record in the log.

NOTE: It is important that the log for each altimeter is complete, accurate and up-to-date as these logs may be used for future trajectory analysis studies.

6.1.2 Test Considerations

a. Particular consideration shall be given to the sequence of testing in order that:

1) Results of a prior test will be available for the next test.
2) Data shall be logically obtained and presented so that they may be used for future missile trajectory analysis.

b. Evaluation testing shall be conducted with due regard to altimeter design, purpose, maintenance, and operating conditions under which it will be used.

c. Since an altimeter in use functions to measure pressure changes and convert pressure mechanically into meters or feet of altitude, this condition shall be simulated while testing.

6.1.3 Test Conditions

The test conditions that are required for altimeter evaluation are classified in three general categories:

a. Tests shall be conducted at room ambient conditions to obtain standard data that shall be used for later comparison purposes.

b. Tests shall be conducted in a specified environment and then compared to the results of similar tests previously conducted at room ambient conditions. This is to determine the extent of degradation if any, the specimen suffers while operating under environmental conditions.

c. Operational tests shall be conducted under room ambient conditions, after a specimen has been tested in a specified environment, to determine whether the specimen suffered any permanent damage from having been exposed to the environment.

NOTE: 1. Environmental tests shall be conducted in accordance with applicable MTP.

2. The results of all these tests shall be recorded.

6.1.4 Facilities and Equipment

a. Test personnel shall adhere to the use of specified test

facilities and equipment insofar as these have proven effective through previous use.

b. Test equipment shall be accurate to a magnitude ten greater than the function being measured.

6.2 TEST CONDUCT

6.2.1 Resistance, Output Impedance, and Insulation Tests

a. Resistance

1) Depending on the accuracy required, a voltmeter or a resistance bridge shall be used to measure the resistance across various electrical terminals.
2) Record the resistances measured.

b. Output Impedance

1) Measure voltage with load switch (S_1) open (See Figure 1)
2) Close switch S_1 and adjust the variable load until one half the voltage reading obtained with S_1 open is indicated.
3) Measure and record the resistance of the variable load.

c. Insulation Tests

1) Using a megger, measure and record insulation between any one terminal of the electrical circuit and the altimeter case or bonding strap.
2) Measure and record insulation between electrically isolated circuits.

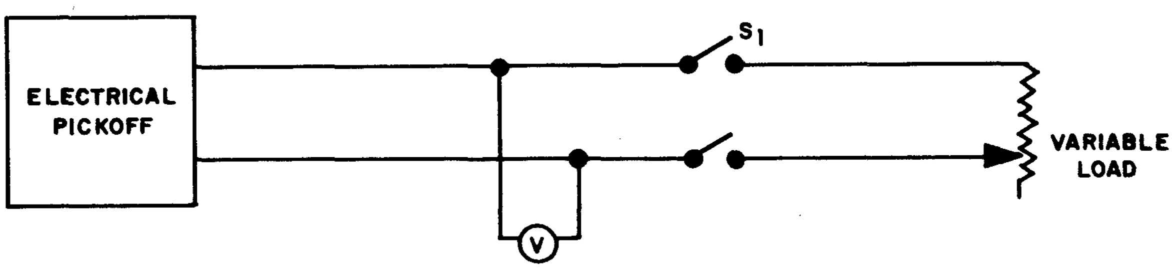

Figure 1. Typical Output Impedance Test Configuration.

6.2.2 Dielectric Tests

a. Using a high potential tester apply 500 volts a-c between the terminals and the altimeter case for 60 seconds minimum.

b. Upon completion of a successful dielectric test, repeat the resistance, output impedance, and insulation tests of paragraph 6.2.1.

6.2.3 Null and Quadrature Voltage Test

NOTE: The quadrature voltage test is conducted only on altimeters having an a-c electrical pickoff.

a. Connect equipment similar to that shown in Figure 2 to the static port of the altimeter.

b. Adjust static pressure to simulate an altitude of approximately 50 percent of the altimeter range.

c. Adjust the altimeter flight level preset dial for a minimum null voltage measured across the output terminals and record this voltage.

NOTE: It may be necessary to measure the output voltage with a dummy load impedance connected across the output terminals.

d. The minimum voltage readings shall be recorded. If the null voltage is near the excess of tolerance of the applicable specifications further testing shall be conducted to determine the component of quadrature voltage existant.

e. Repeat this test simulating zero and full amplitude range of the altimeter being tested.

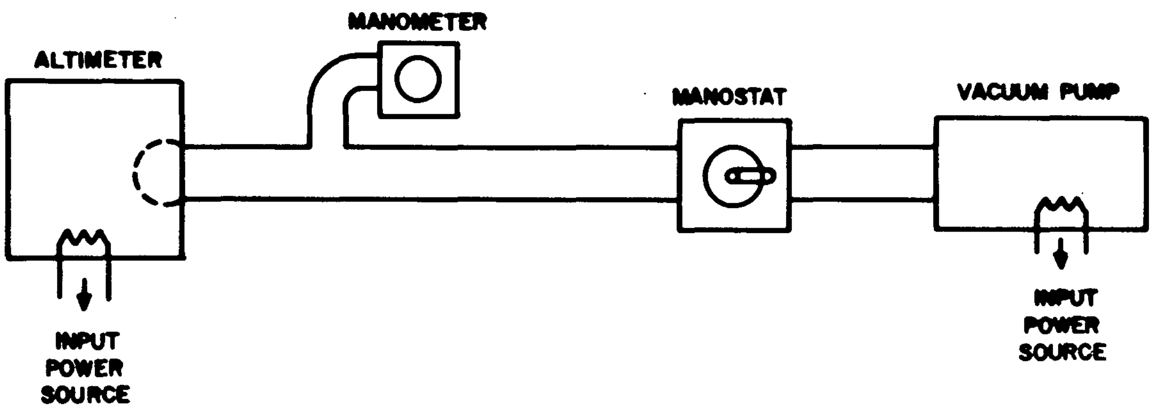

Figure 2. Typical Test Configuration for Tests 3.6.3 through 3.6.9.

6.2.4 Gradient and Linearity Test

NOTE: For purposes of clarification, let it be assumed that the altimeter under test has a range of zero to 80,000 meters.

a. Connect equipment similar to that shown in Figure 2 to the static port of the altimeter.

b. Adjust the flight level preset dial to a predetermined flight level indication, at about one-fourth full range (18,000 meters).

c. Regulate the pressure until the altimeter output voltage reaches electrical null, simulating the altitude at which the preset dial was set.

d. When electrical null is reached, accurately read the manometer to the absolute pressure at which electrical null was obtained.

e. Reduce the manometer reading to altitude expressed in meters and record this value.

f. By adjusting the manostat, vary the static pressure to simulate changes of altitude both above and below the original manometer reading where electrical null was obtained, by an amount equal to the upper and lower limits by the applicable specification.

g. The upper and lower limits of the altitude change shall be predetermined from the altimeter specification (say ±300 meters), and the range within these limits divided into ten equally spaced increments of distance above or below the flight level or preset dial setting.

h. These increments shall be converted into units of absolute pressure commensurate with the unit system of the manometer scale and recorded.

NOTE: 1. If the scale is in inches of mercury then the aforementioned altitude shall be reduced to inches of mercury and subtracted or added to the above manometer null pressure measured at electrical null. This procedure provides a ready reference in which to preset the manometer mercury level when all the required manometer settings are properly tabulated on a test data sheet.

2. When the laboratory instruments measure altitude pressure in inches of mercury (in. Hg), reference will have to be made to NACA Report No. 538 when simulating any altitude levels. This is because the altitude pressure curve is dependent on two variables, height and density. Report No. 538 expresses altitude in feet and pressure in in. Hg. and in 500 - foot increments. Refer to paragraph 6.4.4 for sample calculations and Figure 6 which illustrates typical gradient and linearity test data.

i. Increase the simulated altitude, in steps, by lowering the static pressure by means of the manostat until the manometer indicates each preset level as previously determined for increased altitude.

j. When the upper altitude limit is reached, lower the simulated altitude to null by reversing the previous procedure.

k. Continue through null to the successive mercury levels as previously determined for simulated altitudes below the null reference.

l. When the lower limit is reached, raise this simulated altitude again to obtain null output voltage by reversing the previous procedure.

m. Continue through null to the successive mercury levels as previously determined for simulated altitudes below the null reference.

n. When the lower limit is reached, raise this simulated altitude again to obtain null output voltage by reversing the last portion of this procedure.

o. At each level of altitude change, above and below the null reference, measure and record, successively, each output voltage throughout the cycle.

p. Conduct like tests with the flight level monitor dial set at

three other appropriate flight levels (for example, 40,000, 60,000 and 77,000 meters).

6.2.5 Hysteresis and Striction Test

a. Connect equipment similar to that shown in Figure 2 to the static port of the altimeter.

b. The flight level preset dial of the altimeter shall be set to the lowest flight level used in the gradient and linearity test, paragraph 6.2.4 (18,000 meters in example previously cited).

c. Null the altimeter output voltage by adjusting the input static pressure.

d. Record the manometers indication (for example in inches of mercury) for the voltage output just obtained as the original null reference.

e. Reduce the static pressure until the manometer indicates an altitude change of 300 meters above what it was at the original null reference.

f. Increase the pressure until, for a second time, the manometer indicates an altitude of exactly 300 meters below the original null reference.

g. Record the output voltage as E_1.

h. Continue to increase the input pressure until the manometer indicates an altitude of exactly 300 meters below the original null reference.

i. Lower the pressure until the manometer again indicates exactly the same value of absolute pressure as at the original null reference.

j. Record the output voltage at this third pressure adjustment for null reference as E_2.

k. Repeat steps a-j with the flight level preset dial set at the exact flight levels used in paragraph 6.2.4 that is at 40,000, 60,000, and 77,000 meters.

6.2.6 Absolute Accuracy Test

a. Connect equipment similar to that shown in figure 2 to the static port of the altimeter.

NOTE: Most altimeters have a tab which permits adjustment for ambient barometric pressure.

b. Adjust the barometric tab to 29.92 in Hg. (sea level) and set the flight level preset dial to zero altitude.

c. Adjust the static pressure until altimeter output voltage electrical null is obtained.

d. Read the pressure and convert to altitude in meters, paragraph 6.4.4.

e. Record this level as altitude A.

f. Without disturbing the setting of the barometric pressure tab, adjust the flight level preset dial to simulate some altitude within the altimeter range.

g. Again adjust static pressure until voltage null is obtained.

h. Read the pressure for the altitude simulated and convert to altitude in meters.

i. Record this level as altitude B.

j. Repeat this procedure to simulate any other three altitude levels and designate the results, altitudes C, D and E respectively.

6.2.7 Polarity, Phase, Shift and Reversal Test

a. Connect equipment similar to that shown in Figure two to the static port of the altimeter.

b. Connect an oscilloscope to the altimeter so that the Y axis indicates input voltage and the X-axis indicates output voltage.

c. Adjust the oscilloscope for a Lissajou pattern.

d. Adjust the flight level preset dial tp approximately 25 percent of the altimeter altitude range.

e. Adjust static pressure to obtain output voltage electrical null.

f. Increase static pressure until the output voltage is at a level convenient to read.

g. Record the polarity relationship and the phase shift observed on the oscilloscope.

h. Decrease static pressure until the altimeter output voltage is at a convenient level to read.

i. Record the phase shift and polarity relationship observed on the oscilloscope.

j. Decrease static pressure until the maximum altitude is simulated.

k. Record the phase shift and polarity relationship observed on the oscilloscope.

l. Increase static pressure until zero altitude is simulated.

m. Record the phase shift and polarity relationship observed on the scope.

6.2.8 Waveform Test

a. Connect equipment similar to that shown in Figure 2 to the static port of the altimeter.

b. Increase static pressure to 29.92 in. Hg. to simulate zero altitude.

c. Adjust the flight level preset dial to obtain maximum output voltage.

d. Use a distortion analyzer to analyze the waveform.

e. The percent of harmonic distortion shall be recorded.

6.2.9 Leakage Test

a. Connect equipment similar to that shown in Figure 2 to the static port of the altimeter.

b. Adjust static pressure to simulate an altitude of 50 percent of the altimeter range.

c. Adjust the flight level preset dial to obtain an electrical null.

d. Record the voltage as E_1.

e. Seal the altimeter hose connections to trap pressure inside the altimeter.

f. Disconnect the vacuum pump supply line.
g. Wait 10 minutes, then read the altimeter output voltage.
h. Record this voltage as E_2.

6.2.10 Transient Response Test

a. Connect equipment similar to that shown in Figure 3 and described in Appendix B to the static port of the altimeter.

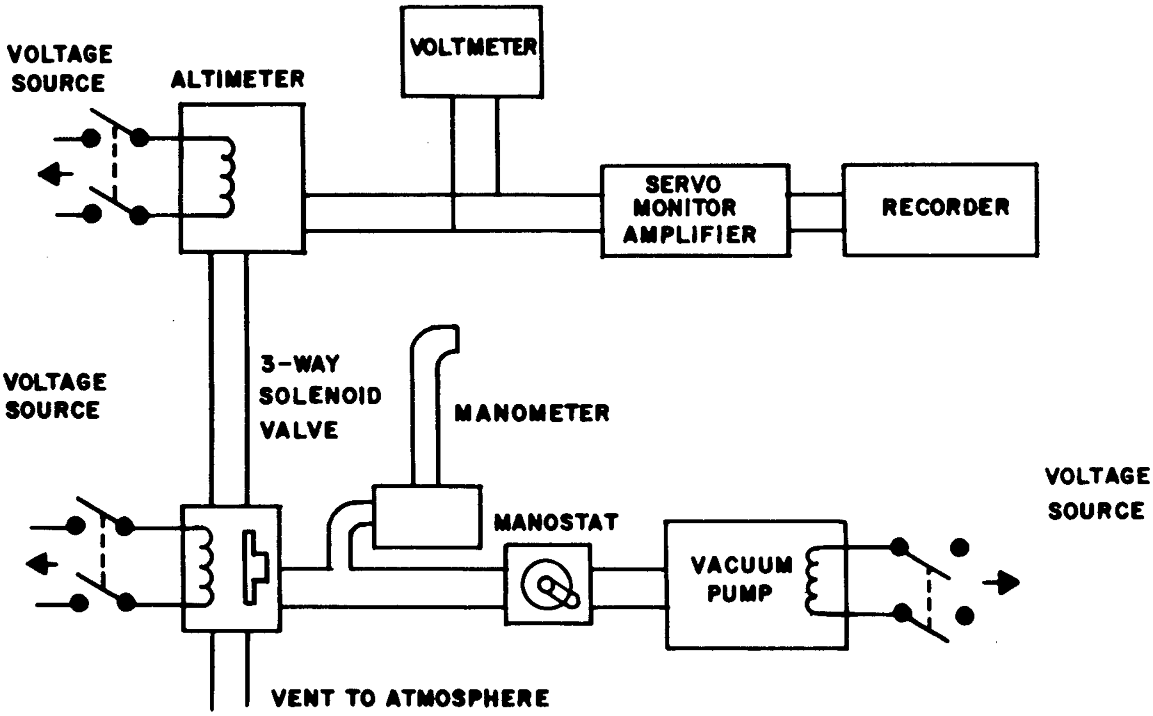

Figure 3. Typical Transient Response Test Configuration. A description of this equipment is contained in Appendix B.

b. Position the solenoid value so that the altimeter is vented to room pressure.
c. Adjust flight level dial until the output voltage null is indicated.
d. Adjust static pressure to near room pressure.
e. Short the input signal to the recorder and center the recorder stylus.
f. Calibrate the recorder to indicate a convenient scale of volts per unit displacement.

NOTE: The recorder will indicate a slight displacement when indicating the output voltage null signal.

g. Position the solenoid valve to transfer the altimeter from the vent to the vacuum pump.

h. Decrease the static pressure to simulate a small increase in altitude and measure and record the altimeter output voltage.

i. Start the recorder and adjust for a suitable rate of paper speed.

j. Position the solenoid valve so that the altimeter is vented to room pressure and the vacuum pump line is closed. A timing mark shall be made on the recorder sheet at the moment the altimeter is vented.

k. Stop the recorder after the step input is recorded.

l. Recalibrate the recorder for a higher simulated altitude.

m. Position the solenoid valve to transfer the altimeter from vent to the vacuum pump.

n. Decrease static pressure to simulate an altitude of approximately 35 percent of the altimeter range and measure the output voltage.

o. Start the recorder and adjust for a suitable rate of paper speed.

p. Position the solenoid valve so that the altimeter is vented to room pressure and the vacuum pump line is closed. A timing mark shall be made on the recorder sheet at the moment the altimeter is vented.

NOTE: If the proposed method proves unsatisfactory, in that pressure is not exhausted or dumped quickly enough, an alternate method may have to be employed. The alternate method incorporates dumping the pressure by suddenly severing the exhaust hose line by means of a sharp instrument, such as an axe.

q. The recorder chart shall be removed for analysis.

6.2.11 Frequency Response Test

a. Connect equipment similar to that shown in Figure 4 and described in Appendix B to the static port of the altimeter.

b. Open valves V_1, V_2, V_3.

c. Set pressure variator to the mid or relaxed position of its throw.

d. Position the 3-way solenoid valve so that the vent orifice is closed and the vacuum pump orifice is open.

e. Position the preset dial of the altimeter for some predetermined simulated altitude.

f. This altitude shall be 15 percent of the full range of the instrument.

g. Start the vacuum pump by means of the manostat.

h. Adjust the pressure, indicated by the manometer, for the simulated altitude.

i. If necessary, adjust the altimeter preset dial for an electrical null output voltage.

j. By means of the manostat, vary the simulated altitude a suitable increment of change above and below the altitude of null and adjust the Pressuregraph pickup head to get a good signal on the oscilloscope.

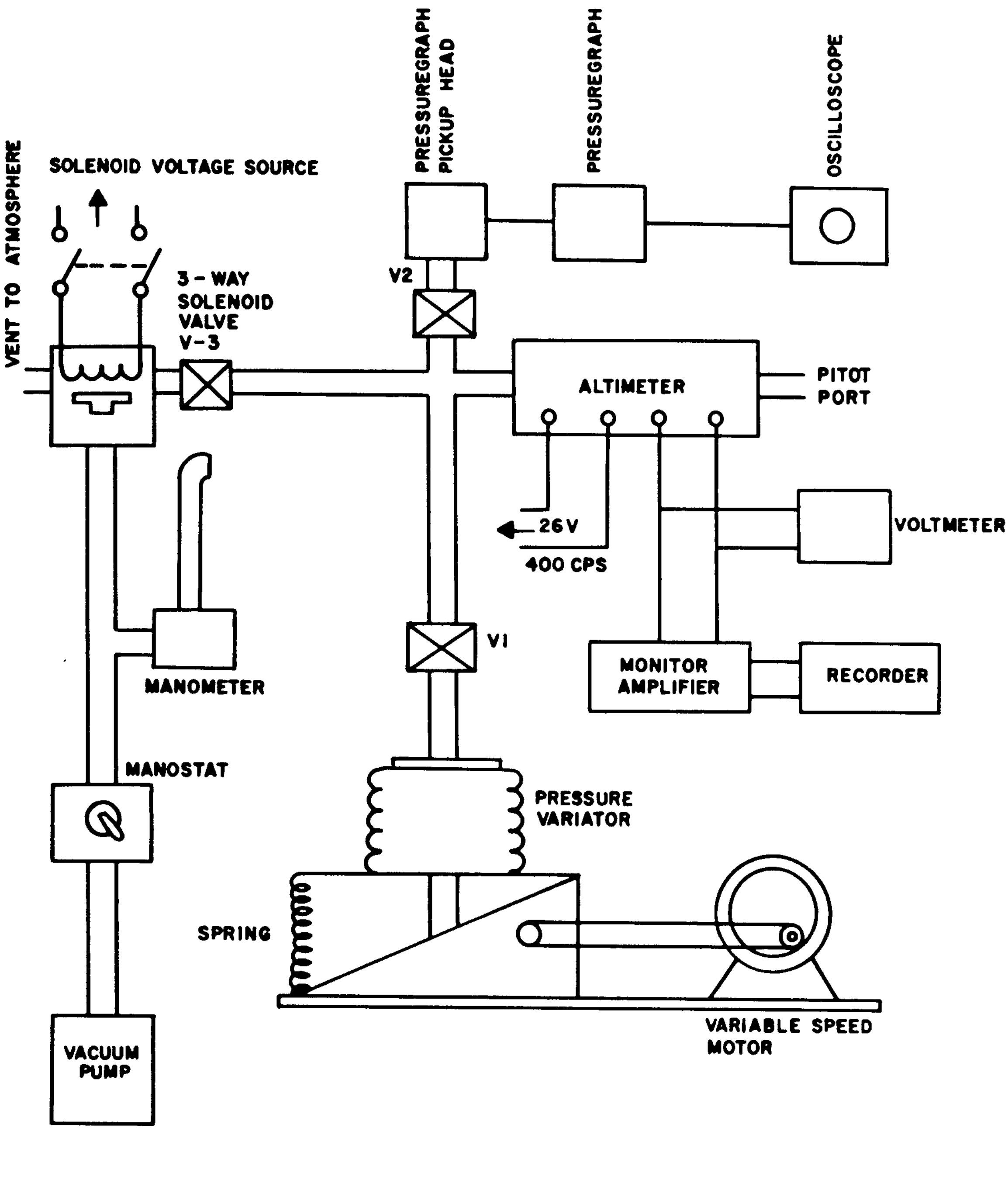

Figure 4. Typical Frequency Response Test Configuration

k. Refer to the Pressuregraph manual and select the proper diaphragm for use with the range of pressure and frequency expected.

l. Center and calibrate the Sanborn recorder for a convenient stylus displacement.

m. By means of the manostat, adjust the pressure for null output and assure that the pressure variator is at the center of its throw.

n. Close valve V_3 and slowly operate the pressure variator, adjusting its throw until the oscilloscope displays a signal of the same amplitude as was previously obtained with the manostat.

o. Determine the frequency range through which the frequency response test shall be conducted, from information furnished on the particular missile system and from specification requirements of the altimeter being tested.

p. Start the recorder at a relatively low chart speed and start the pressure variator to cycling at the lowest frequency to be used.

NOTE: The amplitude of the pressure waveform as observed on the oscilloscope shall remain constant.

q. Increase the frequency of pressure cycling and take recordings at about ten equally spaced intervals of the frequency spectrum being investigated.

r. Continue changing speed until the maximum proposed frequency range is reached.

s. All chart speeds, frequencies, and amplitudes shall be indicated on the recorder chart.

t. The recorder chart shall be removed for analysis.

6.2.12 Life Cycling Test

a. Connect the altimeter to a life cycling timing device as shown in Figure 5. This device shall be capable of controlling the cycling at a rate of four cycles per minute.

b. Electrically energize the altimeter.

c. Refer to applicable specifications to obtain the range of each cycle and number of cycles of operation.

NOTE: The typical test requirement is a range on the order of sea level to 500 meters of altitude and 15,000 cycles of operation.

d. Interpret the cycling every 3000 cycles of operation and conduct a linearity test (paragraph 6.2.4) to see if any degradation has occurred.

e. A linearity test shall be conducted at the conclusion of the life run.

NOTE: Linearity need only be conducted at one altitude during interim check tests but the complete linearity test shall be reconducted at the end of the life cycle test.

f. Observe and record any evidence of bellows or capsule fatigue.

g. Connect an oscilloscope across the output load resistor of the altimeter if the pickoff is of the d-c potentiometer variety.

h. Observe and record any noise spikes on the waveform.

i. Check for electrical noise and discontinuity of pickoff circuitry if it is an a-c type.

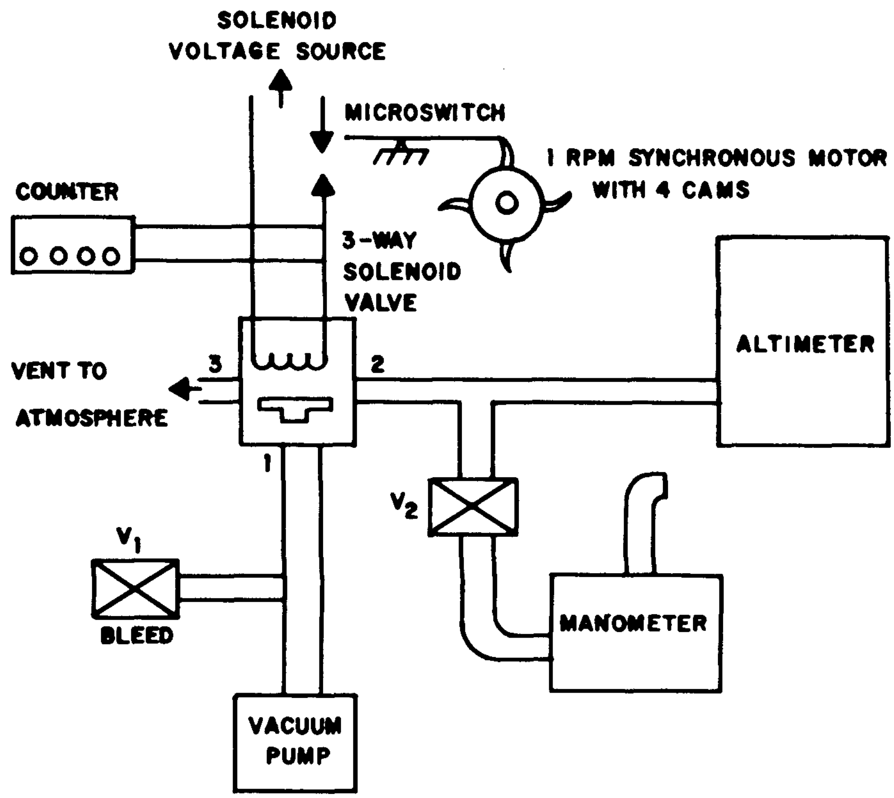

Figure 5. Typical Life Cycling Test Configuration

6.3 TEST DATA

6.3.1 Preparation for Test

6.3.1.1 General

The following data shall be recorded for each Altimeter tested:

a. Number of starts
b. Date
c. Running Time
d. Resistance
e. Voltage
f. Pressure
g. Altitude
h. Measurements or indications

i. All flight level preset dial settings at which tests are conducted.

j. Pressure settings at which tests are conducted

6.3.1.2 Visual Examination

Record any evidence of corrosion, physical damage, and non-conformance with design specifications.

6.3.1.3 Test Conditions

The results of testing the specimen under differen environmental conditions shall be recorded.

6.3.2 Test Conduct

6.3.2.1 Resistance, Output Impedance, and Insulation Tests

a. Resistance - Record the resistances measured.
b. Output Impedance - Record the resistance of the variable load.
d. Insulation Tests - Record insulation between electrically isolated circuits.

6.3.2.2 Dielectric Tests

Data shall be recorded as described in paragraph 6.2.2.1.

6.3.2.3 Null and Quadrature Voltage Test

Record all minimum voltage readings.

6.3.2.4 Gradient and Linearity Test

a. Record the value of the manometer reading when the altimeter has reached electrical null.
b. The increments of the altimeter range to be used for testing shall be recorded.
c. At each level of altitude change, above and below the null reference, record, successively, each output voltage throughout the cycle.

6.3.2.5 Hysteresis and Striction Test

a. Record the first manometer indication for the voltage output as the original null reference.
b. Record the second and third output voltages as E_1 and E_2.

6.3.2.6 Absolute Accuracy Test

Record each altitude simulated as altitudes A, B, C, D and E respectively.

6.3.2.7 Polarity, Phase Shift, and Reversal Test

Record the polarity relationship and the phase shift for each altitude simulated.

6.3.2.8 Waveform Test

The percent of harmonic distortion shall be recorded.

6.3.2.9 Leakage Test

Record voltages E_1 and E_2.

6.3.2.10 Transient Response Test

The recorder chart shall be removed for analysis.

6.3.2.11 Frequency Response Test

a. Chart speeds, frequencies and amplitudes shall be indicated on the recorder chart.
b. The recorder chart shall be removed for analysis.

6.3.2.12 Life Cycling Test

a. Record data as specified in paragraph 6.3.2.4.
b. Record any evidence of bellows or capsule fatigue.
c. Record any noise spikes observed on the waveform of d-c type pickoffs.
d. Check for electrical noise and discontinuity of a-c type pickoffs.

6.4 DATA REDUCTION AND PRESENTATION

An altimeter being tested must meet all applicable specifications requirements for it to be suitable for use. All test results shall be compared to Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR) and Technical characteristics (TC).

During specific tests, the resulting data may require conversion to other units for convenience of analyzing. In other tests, the data obtained will require presentation in graphic or chart form to permit proper analysis.

Charts, graphs and conversion calculations explained in the following paragraphs will become a permanent record in the log folder. It is important that the log for each altimeter is completely accurate and up-to-date as these logs may be used for future trajectory analysis studies.

6.4.1 Resistance Output Impedance and Insulation Tests

a. Resistance - Consult the electrical schematic or applicable

specification for resistance values and compare to those measured during test.

b. Output Impedance - Maximum transfer of power occurs when the electrical pickoff and the variable load are equal. The resistance measured equals the impedance of the electrical pickoff output. Impedance must be within specification tolerance.

c. Insulation Tests - Values should conform to specification requirements. Generally a value of 30 megohms is considered adequate insulation.

6.4.2 Dielectric Test

No additional data reduction necessary.

6.4.3 Null and Quadrature Voltage Test

The minimum voltages measured shall be compared to specifications to ensure that they are within the tolerance of applicable specification.

6.4.4 Gradient and Linearity Test

a. The NACA Report No. 538 lists altitude measured in feet and pressure measured in inches of mercury or millimeters of mercury at 500-foot increments. The report may be used to convert altitude measurements to pressure values, or pressure values to altitude measurements. For example to determine pressure in in. Hg. for a simulated altitude of 2,500 meters:

1 meter = 3.28 feet
2,500 meters x 3.28 feet = 8,200 feet
From NACA Report No. 538: 8,000 ft. = 22.22 in. Hg.
8,500 ft. = 21.80 in. Hg.
0.42 in. Hg.

$$8{,}200 \text{ ft.} = 22.22 - \frac{0.42 \times 200}{500} = 22.05 \text{ in. Hg.} = 2{,}500 \text{ meters}$$

To determine altitude in meters for a pressure reading of 22.05 in. hg.:

From NACA Report No. 538: 8,000 ft. = 22.22 in. Hg.
8,500 ft. = 21.80 in. Hg.
0.42 in. Hg.

22.22 in. Hg. - 22.05 in Hg. = 0.17 in. Hg.

$$22.05 \text{ in. Hg.} = 8{,}000 + \frac{500 \times 0.17}{0.42} = 8{,}200 \text{ ft.}$$

1 foot = 0.3048 meter
8,200 ft. x 0.3048 = 2,500 meters

b. Data collected during this test are best presented in graphic form for determining the gradient or scale factor as expressed in volts rms per meter of altitude. Figure 6 is a graph presenting typical gradient and linearity test data.

c. Enter the altimeter output voltage on data sheet in appropriate columns to correspond with the related simulated altitude levels.

d. A linearity curve of altitude increments simulated, during this test, in relation to output voltage measured at each altitude shall be plotted on linear graph paper. Use a plus sign (+) to identify data obtained at increasing altitudes and a minus (-) at decreasing altitudes.

e. Note on the graph the tolerance as shown in the applicable specification.

f. A plus and minus tolerance envelope, as determined from the specification requirements, shall also be plotted on the graph to assist in a quick look determination whether or not the specification requirement has been complied with.

g. A gradient or scale factor shall now be determined from the curve expressed as volt rms per meter of altitude or in other applicable units, as the case may be.

6.4.5 Hysteresis and Striction Test

a. Algebraically, determine the difference between the two output voltages ($E_2 - E_1$) of the second and third nulls.

b. By use of the average scale factor determined during the gradient and linearity test, paragraph 6.4.4 reduce the above voltage difference to meters.

c. With reference to the data obtained in paragraph 6.2.5 determine the output voltage spread between E_1 and E_2 at each of four altitude levels where tests were made.

d. Reduce the differences found for each of the four sets of data to meters, using the average scale factors (volts rms/meter) of each respective altitude level.

e. The deviation in meters represents the altimeter hysteresis error. This deviation shall be checked against the specification requirements.

f. The difference between the second and third nulls, represented in meters, for each of the four altitudes simulated is the hysteresis error. Hysteresis error or deviation must not exceed applicable specification requirements.

6.4.6 Absolute Accuracy Test Data

a. Record the data resulting from this test in chart form in the altimeter log for future comparison studies.

b. Use six numbered columns similar to those shown in Figure 7.

c. Column 1 shall list, consecutively, the five preset dial settings, 0, 2000, 4000, etc.

d. Column 2 should list the corresponding five pressure measurements in inches of mercury.

NOTE: It has been assumed that the manometer scale is in inches of mercury

e. In column 3 shall be listed the corresponding converted altitudes designated as A, B, C, etc.

f. Column 4 shall list the comparison tolerance values between

Altimeter		Manometer		Comparison Tolerance	Difference in Meters Between	Tolerance in Meters
Test Symbol	Dial Setting	Pressure In. Hg.	Altitude Meters	Column 3 to Column 1	Consecutive Tests of Column 3	for Column 5
Col. 1		Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
A	-0-	29.81	30	± 400 meters	B - A = 1,979	2,000(± 80)
B	2,000	23.44	2,009	± 400 meters	C - B = 2,005	2,000(± 80)
C	4,000	18.29	4,062	± 400 meters	D - C = 1,942	2,000(± 80)
D	6,000	13.99	6,004	± 400 meters	E - D = 2,011	2,000(± 80)
E	8,000	10.50	8,016	± 400 meters	C - A = 4,032	4,000(± 80)
					D - B = 3,995	4,000(± 80)
					E - C = 3,954	4,000(± 80)

Figure 7. Typical Absolute Accuracy Test Data

column 3 and column 1.

NOTE: These tolerance values should be called out in the specification requirements of the particular altimeter being tested.

g. Column 5 shall list the difference in meters between consecutive altitude values of column 3 (i.e., B-A, C-B, D-C, etc.).

h. Column 6 shall list the tolerance in meters for column 5, (i.e., B-A = 2000 meters ± 80 meters, C-B = 2000 meters ± 80 meters, etc.).

i. The tolerance values for column 6 shall be determined from the specification requirements of the particular altimeter being tested.

6.4.7 Polarity, Phase Shift and Reversal Test

a. The polarity relationship and phase shift shall be within specification tolerance.

b. When the static pressure is increased until the output voltage is at a level convenient to read, an out-of-phase or inphase relationship should have been observed.

c. When the static pressure is decreased until the output voltage is at a level convenient to read, a phase shift or reversal of 180 degrees should have been observed on the oscilloscope.

d. No phase shift or phase reversal should be observed while simulating maximum altitude.

e. While increasing the pressure no phase shift or phase reversal should occur except when passing through the altimeter electrical null at preset altitude.

6.4.8 Waveform Test

The percent of harmonic distortion must be within specification requirements.

6.4.9 Leakage Test

Subtract the null voltage from the second voltage (E_2-E_1). The voltage difference represents the altimeter leakage and must not exceed specification requirements.

6.4.10 Transient Response

Referring to the recorder chart, the altimeter output voltage should stabilize to a minimum value near null within a short time interval. This interval is the transient response time. For each step input compare the time interval with the applicable specification to determine if the transient response time is within tolerance.

6.4.11 Frequency Response

a. Analyze the chart for frequency response by plotting a frequency response curve, amplitude ratio versus frequency on 3-cycle semilog graph paper and comparing the curve obtained to a family of typical curves pertaining to the response of a simple resonant system.

b. Plot the frequency on the three-cycle X-axis (abscissa) while the amplitude ratio is plotted as the ordinate along the Y-axis of the graph.

c. Analysis of the curve will reveal the following characteristics of the altimeters:

1) Frequency response
2) Damping coefficient
3) Natural resonant frequency

6.4.12 Life Cycling Test

No additional data reduction necessary.

APPENDIX A

DESCRIPTION OF MISSILEBORNE PRESSURE ALTIMETERS

The basic type of altimeter used in aircraft and missile control systems is the pressure altimeter or aneroid barometer. An altimeter is generally designed to sense the value of atmospheric pressure at some preset or preselected flight level and interpret this sensed value in terms of distance above or below the preset pressure level reference. The pressure type of altimeter, as used in missile control systems functions to constantly monitor altitude and furnish an electrical signal to other missile components. The signal is often utilized in a pitch fin command to control a missile or aircraft at a preset altitude during its midcourse flight.

The electrical pickoff of the altimeter is usually of the variable reluctance type utilizing 400-cps a-c voltage; however, this does not preclude the use of other types of pickoffs, such as the d-c or a-c potentiometer, microsyn or capacitance bridge type. The sensing element of this type altimeter generally comprises an airtight chamber from which most of the air has been removed to which is affixed a gear or lever system which in turn drives the pickoff.

APPENDIX B

TYPICAL TRANSIENT AND FREQUENCY RESPONSE TEST CONFIGURATIONS

The equipment shall be connected to the static port of the altimeter, similar to that, as shown in Figure 3. The static port of the altimeter shall be connected to a three-way, solenoid operated valve that will function to provide a connection to either a vent at room pressure on a vacuum pump, but not to both simultaneously. The solenoid valve shall have large orifices and be connected to the altimeter port through short lines. A suitable aneroid manostat shall be connected into the vacuum line between the pump and solenoid valve. A manometer shall be connected to monitor the pressure between the aneroid manostat and the solenoid valve. The amplifier monitors the altimeter a-c output voltage and provides a d-c output signal to the recorder.

For determining the frequency response the test setup used for transient response test shall be retained and the following additions and modifications made.

The solenoid valve connection to the altimeter static port may be temporarily removed. To the static port connection, provide a multiple connection terminated by three hand valves, V_1, V_2 and V_3. Replace the solenoid valve connection to valve V_3. To valve V_2 connect the pickup head of an instrument, such as an Electro Products Lab Model 3700-C Pressuregraph. The output of the Pressuregraph must be connected to an oscilloscope for observing and displaying the pressure waveform. To valve V_1, connect a pressure variator. The pressure variator is any device designed and constructed to sinusoidally vary (within an adjustable range) the existing pressure of the system over a range of frequencies. A typical design incorporates a variable speed motor connected through a reciprocating mechanism to drive a bellows.

Figure 4 suggests a test setup.